Space Weather Technical Forecast

Issued on Saturday, 09 December 2023 at 01:06 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of R1-R2 throughout. Chance of S1 given recent M5.4.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as measured by GOES16 and 18, rose to Moderate in the past 24 hours, with occasional C-class flares observed for the most part, markedly broken by an M5.4 from AR3511 at 08/2307UTC.

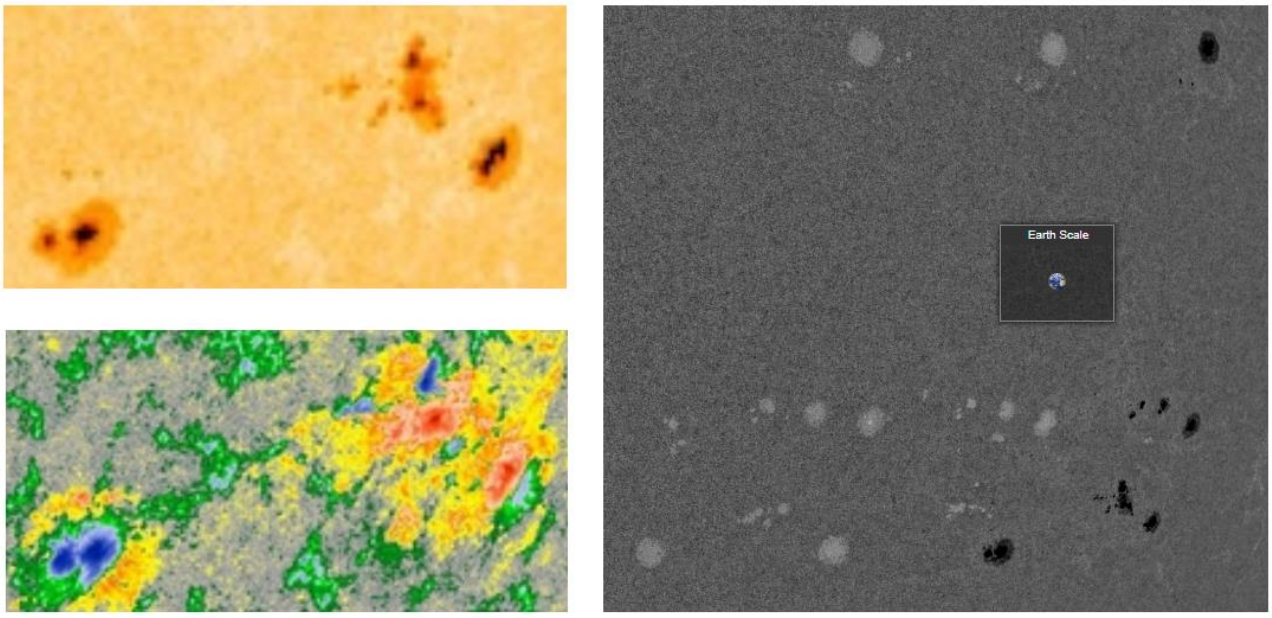

Figure 0: Clockwise from top left, 08/2400UTC HMIIF of AR3511, with possible delta spot in the left leading group; Helioviewer.org-generated HMIIF footprint difference imagery for the current time (black), 24 hours ago and 48 hours ago, showing recent rapid growth in the previous stable leading portion of AR3511 (southernmost active region, with AR3507, AR3508 and AR3510 also shown); HMIBC imagery of AR3511 at 08/2400UTC.

There are now eight numbered regions on the disc, with AR3515 and AR3516 attaining numbers in the period on the southeastern limb. At present, these appear unipolar, although AR3516 may shortly reveal a trailing spot and bipolarity judging by its plage. The main changes in the past day have been proliferation in the leading portion of AR3511 in the southwest, with a possible tenuous delta spot now appearing, perhaps the main reason for its M5.4 parting shot at the UTC working week. Also of note were minor proliferation in the trailing portions of AR3514 and AR3513 in the northeast.

There were a number of prominence and filament eruptions in the past 24 hours, with these mainly

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from the southwest limb during the UTC early hours, followed by a large filament slowly lifting off from the northwest around 08/0300UTC. Perhaps most notably, a filament from south centre-disc was then seen to erupt around 08/0500UTC on Learmonth H-Alpha imagery (for example), with an associated coronal dimming in AIA211. The earlier prominence and filament activity was determined not to be Earth-directed, while the final more significantly-placed event could not be located on coronagraph imagery and may instead have been re-absorbed.

Later in the period, a large partial halo into the UTC evening was likely associated with far-sided activity, with no obvious source region on the Earth-facing side, with a final prominence lift off occurring on the northwestern limb around 08/2100UTC. No obvious ejecta was visible associated with the M5.4, however this is now a main source of monitoring along with any proton response.

Despite this activity, no new Earth-directed Coronal Mass Ejections (CMEs) were in evidence.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, have continued to be reflective of a gradual exit from a fast solar wind regime, thought to be that from CH76/-, with the phi angle towards the Sun throughout (negative). The solar wind speed showed a decline through Slightly Elevated levels in the 24 hours, falling from 475 to 425km/s, with the density near the long-term average in single figures ppcc. The IMF showed a roughly level tendency near background below 5nT, while the north-south component ranged between +3 and -4nT.

The net result of the above solar wind measures was provisionally Quiet throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels.

GOES16 high energy (greater than 2MeV) electron flux was predominantly at Moderate levels, but very briefly reached High levels, peaking at 1400pfu at 08/1520UTC. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu), but with a gradual upward trend. The observation at 09/0001UTC was 6.63e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Chance of further M-class flares, with potential sources most likely to be AR3511 given its marked leader growth, and perhaps also AR3513. Chances drop slightly on day four (Tuesday 12 December), with the expected departure of several western solar hemisphere regions including AR3511, and a relative lack of oncoming eastern limb replacements.

Solar Wind / Geomagnetic Activity: There is one marginal CME in the forecast, with a glancing blow from the 07 December northeastern quadrant filament perhaps coinciding with a CIR from the high speed stream leading CH77/+ late on Sunday 10 December. Elevated speeds may be reached, with the combined effect perhaps resulting in a peak Slight Chance of a G1/Minor Geomagnetic Storm interval, perhaps with a tail into Monday 11 December that may further be extended by any fast wind from small CH80/+.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux now carries an increased Chance of S1 given the recent M5.4 flare, with any resultant proton enhancement possibly manifesting at GOES16 in the coming 12 hours or so. This should relax to a residual Slight Chance into the new working week, albeit higher than previously advertised given a resurgent sunspot group in a prone position.

Electron flux levels are likely to see diurnal peaks to a similar level to recent days over the coming UTC weekend, probably attenuated at GEO into the new working week given the onset of CME

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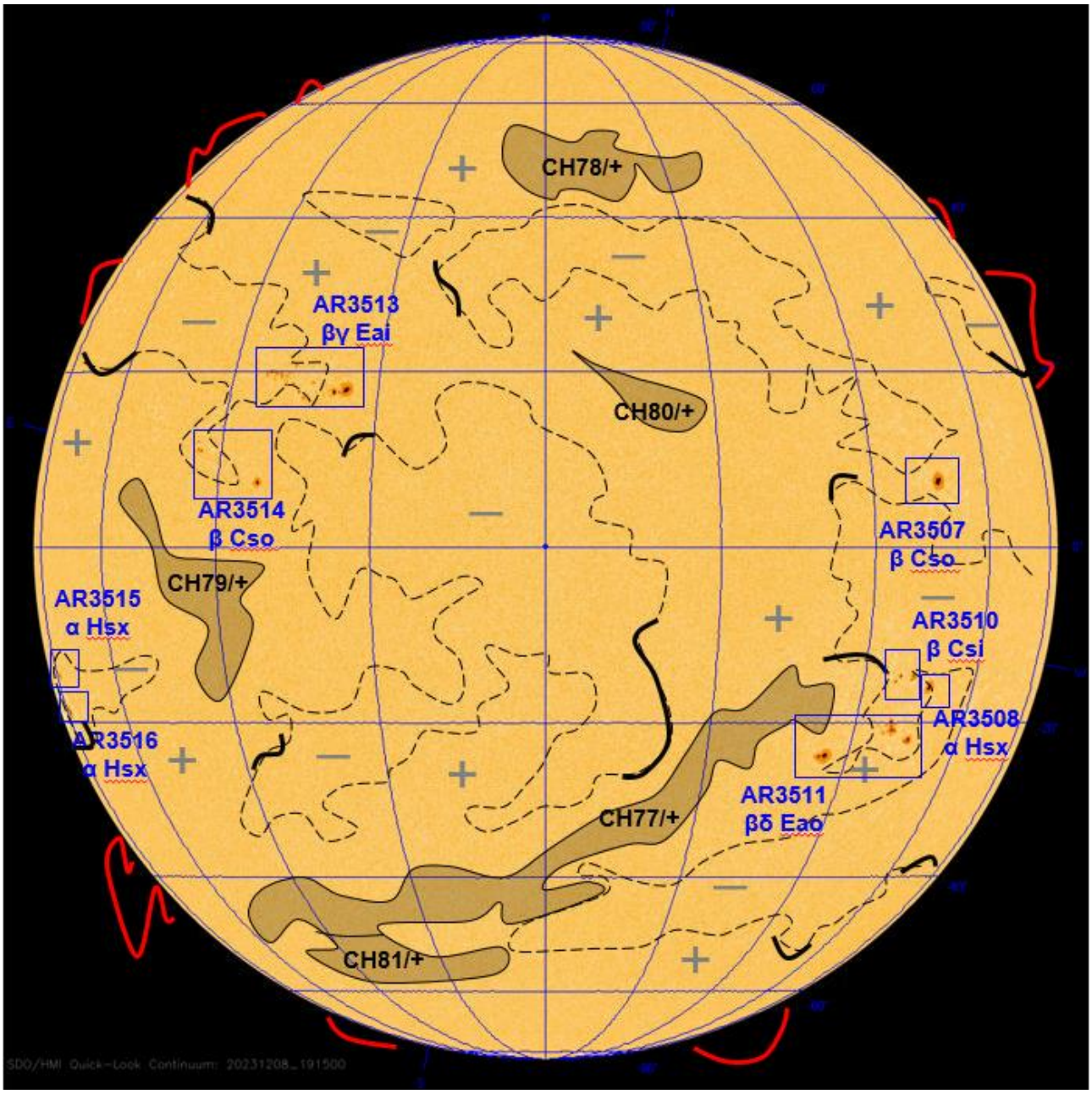
and coronal hole activity.

Figure 1. Solar Analysis Valid 08/1915UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic forecast comprises one possible CME - that from 07/0200UTC seen leaving the northeast quadrant. The weight of evidence from MOSWOC Enlil's ensemble suggests that this could give a weak glancing blow later on Sunday 10 December, although this is likely to be influenced to a large extent by Enlil's handling of the large but well south CH77/+, with some interaction between any CIR leading this feature and the side-lobe of the aforementioned CME possible. This offers a peak risk of G1 for the four-day period, probably continuing into the new working week to some degree, and perhaps further maintained by a small positive coronal hole currently near centre-disc: CH80/+. The most reliably quiet period in the forecast is therefore the start of the UTC weekend, with confidence falling more sharply than is typical with time given the interplay between several marginal features, although confidence in any impact being small is higher.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	20	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
07/1302	Partial	Filament	NE	406 km/s	Late 10 Dec	Low confidence glancing blow

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Figure 2: Latest (08/1800UTC badge time) MOSWOC Enlil and ensemble, showing boxed magenta the 07 December CME and its possible interaction with a CIR leading CH77. Note the relatively minor magnitude of any response.

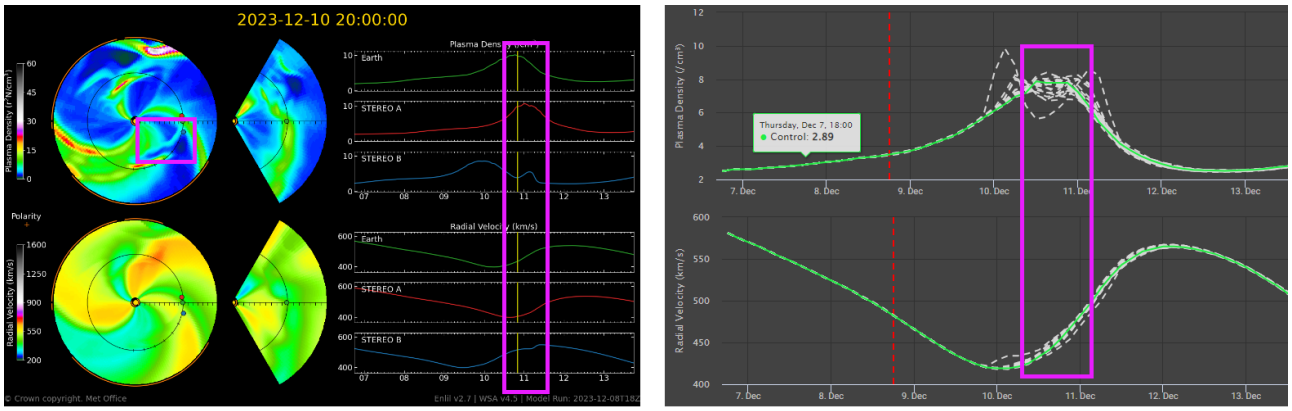
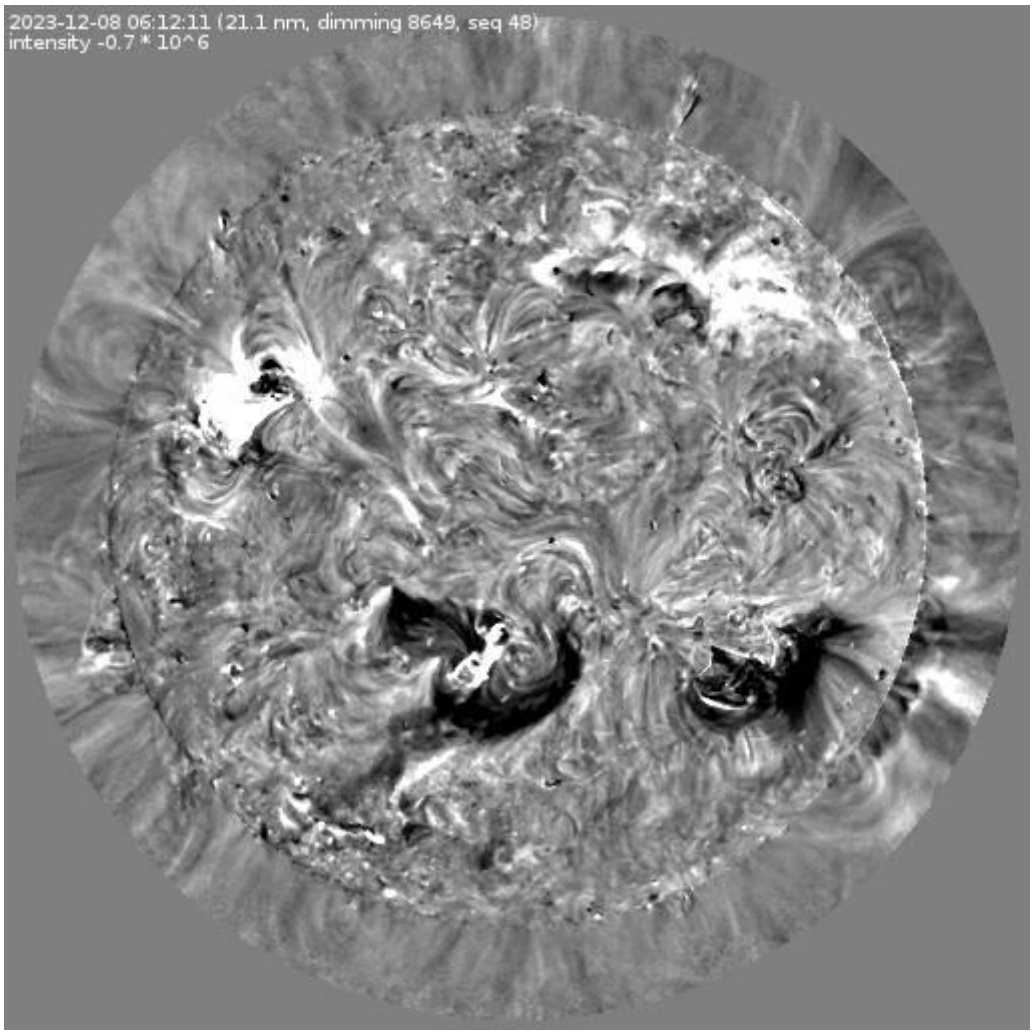


Figure 3: SIDC ROB processed AIA 211 time-integrated dimming of the centre-south disc disappearing filament at 08/0500UTC. There was no obvious correlating CME visible in coronagraphs.



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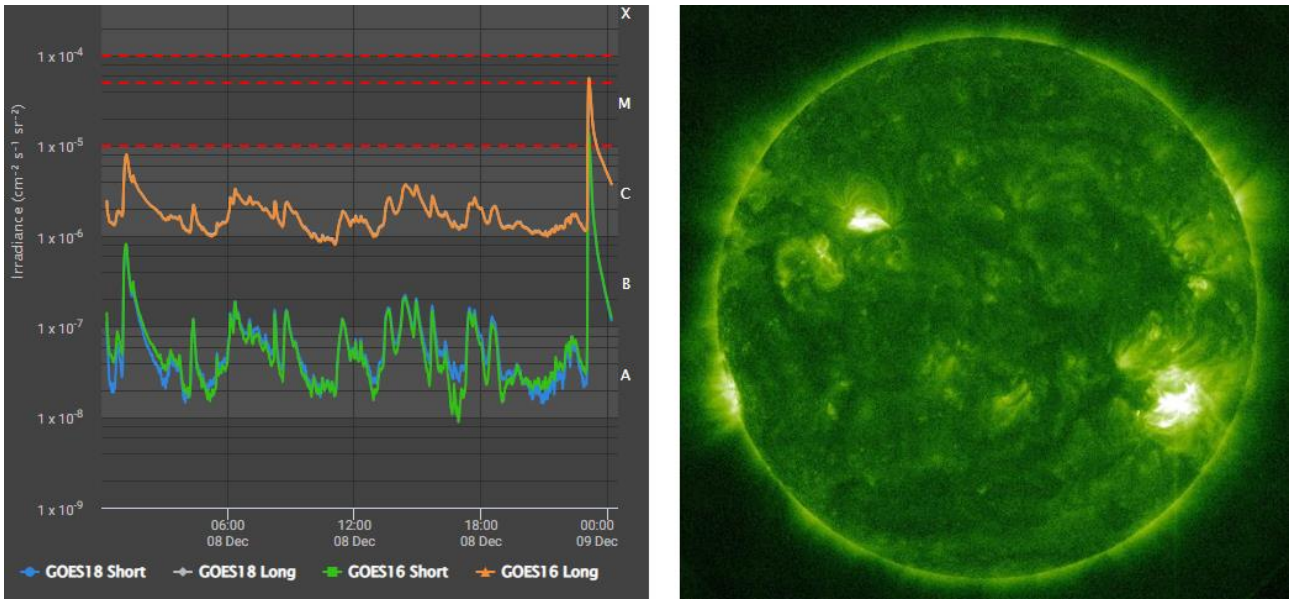
Radio Blackouts - X-Ray Flares:

There are now up to eight sunspot regions on the Earth-facing disc, with activity mainly connected to AR3513 in the northeast, and AR3511 in the southwest. Both showed a proliferation of constituent spots in the past 24 hours, although this was most rapid and pronounced in AR3511, with a candidate for a Mount Wilson delta spot eventually developing as the period reached a conclusion.

Neither far-side soundings nor returning Carrington locations suggest any significant upcoming groups over the eastern solar horizon, while on the west, up to three groups are due to depart on Tuesday 12 December. This is expected to lead to an overall slight drop in the daily chance of M-class flares, broadly defined as a waning Chance through the coming four days.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	50	50	50	40
Very Active	R3 to R5 X Class	No	10	10	10	5

Figure 4: GOES16 and 18 X-ray flux as well as AIA094 imagery of AR3511's M5.4 at 08/2307UTC.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background levels. Because of the late M5.4 from AR3511 at 08/2307UTC, there is now a Chance of S1 being attained, with this likely to be known inside the next 12 hours. This figure should then relax toward background beyond the current UTC weekend.

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There is then a daily Slight Chance of S1/Minor Storm conditions being reached, with AR3511 by far the most likely source given its recent performance and prone position advancing across the western disc (although the increase in the new UTC working week is too slight to manifest in the probability table, which instead shows a relaxation from the risk from the M5.4).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	30	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The now waning fast wind from CH76/- should mean that electron flux levels should plateau near current values over the coming UTC weekend, likely falling narrowly short of Active 24-hour integrated fluence. There is then likely to be suppression at GEO under the twin onslaught of geomagnetic activity arising from a second fast wind (from CH77/+) and perhaps also the 07 December CME.

A gradual recovery should then ensue into the new working week as likely brief geomagnetic activity wanes, although there is the question mark of any further influence from small CH80/+ which may further delay increases at GEO. All considered, coronal holes in the period are considered relatively modest in stature, and the likelihood is that fluence levels remain below Active for the duration.

MOSWOC REFM maintains fluence below 1e8 through the next 72 hours, and persistence shows a precipitous drop, although neither is felt to offer a good handle on upcoming conditions given the possible presence of a CME.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	30	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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